CLAIMS

1. Apparatus for reducing the diameter, rounding or straightening of pipe or tubing by rolling comprising:

(a) a plurality of closely and equally-spaced, long, narrow, parallel-cylindrical rollers in a parallel-cylindrical array, said rollers rotationally supported in bearing means provided in end flanges of a supporting cylinder, the ends of said rollers being positioned on pitch circles of equal diameter, said bearings being supported in part-spherical bushings permitting angular displacement of the ends of said rollers relative to said end flanges, and one or both of said end flanges being rotationally displaceable one to the other in said supporting cylinder, and;

(b) apertures in said end flanges permitting said pipe or tubing to advance continuously through said rollers on a path coaxial with the axis of their said cylindrical array, and;

(c) means to adjust the relative positions one to the other of said end flanges on said supporting cylinder to skewingly displace said rollers and thereby to displace their said central contact zones radially inwards into forceful contact with the external surface of said pipe or tubing, and;

(d) bearing means to rotationally support said supporting cylinder, and;

(e) drive means to drive said supporting cylinder in a rotational sense, thereby causing said central contact zones of said rollers to

pass over and work upon the external surface of said continuously advancing pipe or tubing , and;

(f) sensing means to detect the linear speed of said advancing pipe or tubing, the straightness of said pipe or tubing, the speed of rotation of said supporting cylinder and the finished diameter of said pipe or tubing, and;

(g) control means to control the speed of rotation of said rollers in relation to the speed of advance of said pipe or tubing, the height of said support means and said skewing adjustment of said rollers, and;

(h) support means to support said supporting cylinder, said end flanges, said rollers, said adjustment means, said bearing means, and said drive means such that said axis of said cylindrical array of said rollers is maintained collinear with said axis of said advancing pipe or tubing.

2. Apparatus according to Claim 1 in which said rollers are made of a strong, hard material and are made fully solid or are made solid at their ends and hollow throughout their central parts;

3. Apparatus according to Claim 1 in which two or more of said cylindrical arrays of said rollers are arranged and operated in tandem to treat a said length of advancing pipe or tubing;

4. Apparatus according to Claim 3 in which alternate said cylindrical arrays of said rollers are rotated in opposite senses;

5. Apparatus according to Claim 1 in which said drive means to

drive said supporting cylinder in a rotational sense take the form of an air motor driving through a belt chain or gears;

6. Apparatus according to Claim 1 in which said drive means to drive said supporting cylinder in a rotational sense take the form of an hydraulic motor driving through a belt chain or gears;

7. Apparatus according to Claim 1 in which said drive means to drive said supporting cylinder in a rotational sense take the form of a stepper motor or other form of speed controllable electric motor driving through a belt, chain or gears;

8. Apparatus according to Claim 1 in which said central contact zones of said rollers work upon the external surface of said continuously advancing pipe or tubing in a series of continuous, parallel, overlapping, helical contact paths;

9. Apparatus according to Claim 1 in which the power required to treat said pipe or tubing is significantly less than that required for conventional tube rolling processes;

10. Apparatus according to Claim 1 in which the relative positions of said end flanges one to another are adjusted by means of one or more adjustable-length struts, the two ends of each of which are pivotally fixed respectively to said end flange and to said supporting cylinder;

11. Apparatus according to Claim 10 in which the length of a said strut is manually adjusted by screwing a threaded male part into a threaded female part and locking the adjusted length with a locknut;

12. Apparatus according to Claim 10 in which the length of a said

strut is adjusted through the use of a ball screw and nut arrangement actuated by a stepper motor;

13. Apparatus according to Claim 1 in which power and control signals are transmitted to devices supported on the moving parts of said apparatus through slip-ring means;

14. Apparatus according to Claim 1 in which control signals are transmitted to devices supported on the moving parts of said apparatus through wireless means;

15. Apparatus according to Claim 1 in which said support means comprise a moving frame slideably supported in linear bearings travelling on rails fixed to a fixed frame, said moving frame being displaced in a linear sense by the combined forces generated by the action of said rollers and by the linear motion of said pipe or tubing, sensing means being provided between the two said frames to detect linear displacement of said moving frame and thereby to regulate the speed of operation of said drive means;

16 Apparatus according to Claim 5 in which the speed of operation of said air motor is controlled by control means in the form of a pneumatic valve actuated by displacement of said moving frame in relation to said fixed frame;

17. Apparatus according to Claim 1 in which said support means are adjusted in height to maintain said axis of said cylindrical array of said rollers collinear with the axis of said advancing pipe or tubing;

18. Apparatus according to Claim 17 in which said support means

are raised or lowered by means of manually-operated screw jacks;

19. Apparatus according to Claim 17 in which said support means are raised or lowered by means of jacks incorporating ball screw and nut arrangements and operated by stepper motors;

20. Apparatus according to Claim 18 in which said sensing means are used to detect the straightness of said advancing pipe or tubing and said control means are used to control the operation of said stepper motors to adjust the height of said support means;

21. Apparatus according to Claim 1 in which said support means take the form of only a fixed frame and said supporting cylinder, said end flanges, said rollers, said adjustment means, said bearing means, and said drive means are moveably supported on linear bearings travelling on vertically arranged rails permitting said axis of said cylindrical array of said rollers to be maintained collinear with said axis of said advancing pipe or tubing;

22. Apparatus according to Claim 21 in which the position of said linear bearings on said vertical rails is adjusted by ball screw and nut arrangements driven by stepper motors controlled by said control means;

23. Apparatus according to Claim 1 in which said sensing means include one or more encoders driven by forming rollers on said tube forming mill or by a jockey wheel which travels on said pipe or tubing;

24. Apparatus according to Claim 1 in which said sensing means include measurement means to measure the finished diameter of said pipe or tubing emerging from said apparatus;

25 Apparatus according to Claim 24 in which said sensing means take the form of opposed pairs of rollers attached to the inner ends of radially-arranged linear transducers, said rollers being urged into contact with said pipe or tubing by springs;

26. Apparatus according to Claim 24 in which said sensing means take the form of a laser micrometer;

27. Apparatus according to Claim 24 in which said sensing means take the form of opposed pairs of proximity sensors, each said sensor measuring the gap between its reference face and the external surface of said pipe or tubing;

28. Apparatus according to Claim 1 in which said rollers in a said array are all made with equal external diameters approximately 20 per cent of that of said pipe or tubing to be treated;

29. Apparatus according to Claim 1 in which said rollers in a said array are made in sets with equal external diameters in the range 10 per cent to 40 per cent of that of said pipe or tubing to be treated;

30. Apparatus according to Claim 1 in which said bearing means are situated as closely as possible to a plane passing through said contact zones of said rollers;

31. Apparatus according to Claim 1 in which said bearing means are accommodated in a bearing housing of which an outer part is formed on the inner surface of a cylindrical extension formed on a radial mounting flange and an inner part is formed on the external surface of a radial web fixed to the external surface of said supporting cylinder;

32. Apparatus according to Claim 31 in which a pulley in the form of a cylindrical extension is formed around the outer circumference of said radial web;

33. Apparatus according to Claim 32 in which said pulley is deleted and replaced by a sprocket adapted for driving said apparatus by means of a chain, or a gear adapted for driving said apparatus by means of gears;

34. Apparatus according to Claim 1 in which said rollers are provided at each end with short shafts, said shafts being rotationally supported in bearing means provided in said end flanges of said supporting cylinder, the axial lengths of said short shafts and said bearing means being made sufficiently long to accommodate the axial displacement caused by skewing of said rollers;

35. Apparatus according to Claim 1 in which said rollers are each rotationally supported in individual yokes, each said yoke being pivotally mounted on a shaft passing radially outwards through a bearing provided in said supporting cylinder, said yokes being skewably displaced by force applied through skewing rings pivotally attached to said yokes at their ends;

36. Apparatus according to Claim 35 in which the outer parts of said shafts of said yokes are threaded to engage ball nuts, said ball nuts being driven by one or more stepper motors to radially displace said yokes inwardly or outwardly;

37. Apparatus according to Claim 1 in which an index mark and

complementary calibration marks are provided one on the ends of said end flanges and the other on the end of said supporting cylinder to facilitate the skewing adjustment of said rollers;

38. Apparatus according to Claim 1 in which said rollers are provided with a centrally-located, narrow convex part to permit the application of a more localised force to said pipe or tubing;

39. Apparatus according to Claim 1 in which said rollers are provided with a centrally-located concave part to permit the application of a more dispersed force to said pipe or tubing;

40. Apparatus according to Claim 1 in which said supporting cylinder with its said roller array is fixed to said support means with quick-release attachments and is readily detached from said support means and replaced by another said supporting cylinder with its said roller array adapted for treating pipe or tubing of a different diameter;

41. A method of reducing the diameter, rounding or straightening of pipe or tubing by a process of rolling comprising the following steps:

(a) passing said pipe or tubing in continuous advance at a constant linear speed through a plurality of closely and equally-spaced, long, narrow, parallel-cylindrical rollers arranged in a parallel-cylindrical array with the axis of said pipe or tubing maintained collinear with that of said cylindrical roller array, said rollers being rotationally supported in supporting means and simultaneously skewable to displace their central contact zones radially inwards, and;

(b) skewingly displacing said rollers to bring their said central contact zones into controlled forceful contact with the external surface of said pipe or tubing, and;

(c) rotating said cylindrical array of said rollers at a controlled speed, thereby causing said central contact zones of said rollers to pass over and rollingly work upon the external surface of said continuously advancing pipe or tubing, and;

(d) sensing the linear speed of said advancing pipe or tubing, the straightness of said pipe or tubing, the speed of rotation of said cylindrical array of said rollers and the finished diameter of said pipe or tubing, and;

(e) controlling said speed of rotation of said rollers in relation to the speed of advance of said pipe or tubing, and;

(e) controlling the height of said supporting means to straighten said pipe or tubing, and;

(f) controlling the degree of skewing of said rollers to regulate the finished diameter of said pipe or tubing.

42. A method according to Claim 41 in which said pipe or tubing is unsupported internally by mandrels or the like during said rolling process;

43. A method according to Claim 41 in which the speed of rotation of said rollers is regulated to accommodate combinations of linear speed of advance of said pipe or tubing and degrees of skewing of said rollers;

44. A method according to Claim 41 in which said rolling process is applied to continuous lengths of said pipe or tubing or to discrete lengths of pipe or tubing;

45. A method according to Claim 41 in which said central contact zones of said rollers describe continuous, parallel, overlapping, helical paths along the external surface of said pipe or tubing and locally apply to the external surface of said pipe or tubing a compressive force in excess of the yield stress of its material, thereby causing said pipe or tubing to adopt a set at a smaller diameter;

46. A method according to Claim 41 in which the passage of said central contact zones of said rollers over the outer surface of said pipe or tubing corrects any out-of-roundness of said pipe or tubing and causes its said external surface to be burnished;

47. A method according to Claim 41 in which said speed of rotation of said rollers, said height of said supporting means and said degree of skewing of said rollers are sensed by sensing means;

48. A method according to Claim 41 in which said speed of rotation of said rollers, speed of advance of said pipe or tubing, said height of said supporting means and said degree of skewing of said rollers are controlled manually;

49. A method according to Claim 41 in which said speed of rotation of said rollers, said height of said supporting means and said degree of skewing of said rollers are automatically controlled by control means accepting inputs from said sensing means;

50. A method according to Claim 41 in which multiple units of said cylindrical arrays of said rollers are employed in tandem, said multiple units all rotating in the same sense or alternate said units rotating in the opposite sense.

51. A method according to Claim 41 in which said rolling process is not limited by the diameter, wall thickness or length of said pipe or tubing;

52. A method according to Claim 41 which produces in each pass a greater reduction in the diameter of said pipe or tubing than that achieved by conventional methods;

53. A method according to Claim 41 in which the external surface of said pipe or tubing does not require lubrication during said rolling process;

54. A method according to Claim 41 which can be incorporated into a tube forming mill to provide an immediate post-fabrication treatment of said pipe or tubing;

55. A method according to Claim 41 in which said cylindrical array of said rollers is fixed to said supporting means with quick-release attachment means and is readily detached from said supporting means and replaced by another said cylindrical array of said rollers adapted for treating pipe or tubing of a different diameter;

56. A method according to Claim 41 in which the power required to operate said rolling process is significantly less than that required in conventional rolling processes.